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TOLLEY'S CAVE[1]

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Tolley's Cave is located about 2 miles northwest of Lexington, Rockbridge County, Virginia (Figure 1). At least three other caverns are located within 1 mile of Tolley's Cave. Cave Springs, probably the largest cavern in Rockbridge County, is located 1 mile south of Tolly's Cave, and has three levels. The other two caverns are located in the cliffs along the Maury River, just east and west of Limekiln Bridge.

The Shenandoah Valley lies in the middle of the Appalachian Mountains, that were formed by folding and faulting in Paleozoic time. The Valley, which trends northeast-southwest, was formed by the erosion of less resistant rocks such as limestone and shale. During deformation many zones of weakness such as joints, faults, and belts of crushed rock developed in the limestone. Solution of the limestone has been especially active in some of these zones of weakness, and as a result many caves have formed.

Tolley's Cave is located in the northwest limb of a jointed and faulted syncline. At the upper entrance the bedding has a strike of N. 48° E. and a dip of 14° SE.; at the lower entrance the strike is N. 45° E., and the dip is 14° SE. In general the cavern passages parallel the dominant trend of the joints. The cavern is formed in the Whistle Creek limestone of Ordovician age. This limestone is dark blue, has thin, irregular bedding, and is generally cherty. However, no chert was found in or around the cave. The Whistle Creek is about 82 feet thick in this area. A chemical

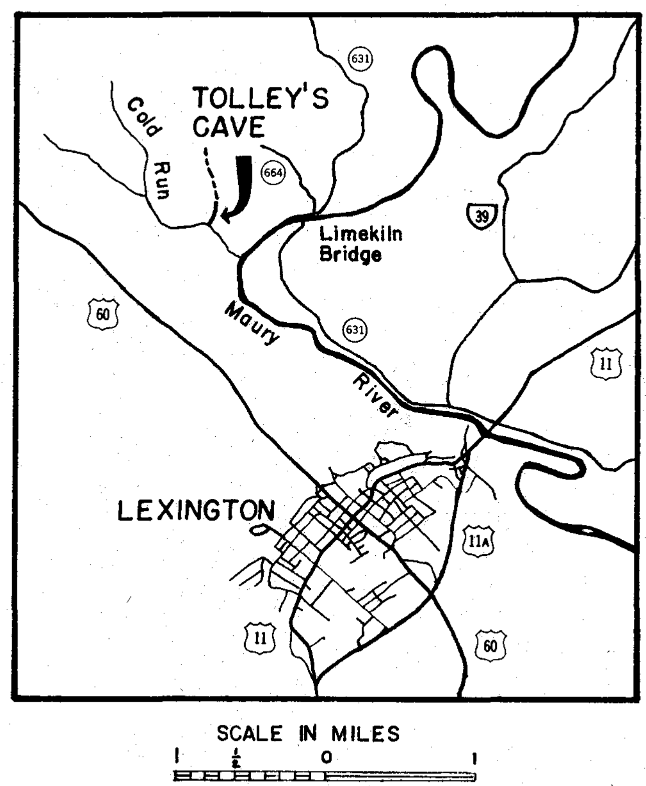

Figure 1. Index map showing location of Tolley's Cave, Rockbridge County, Virginia.

[1] This article is part of a senior thesis submitted in 1963 to the Department of Geology, Cornell University.

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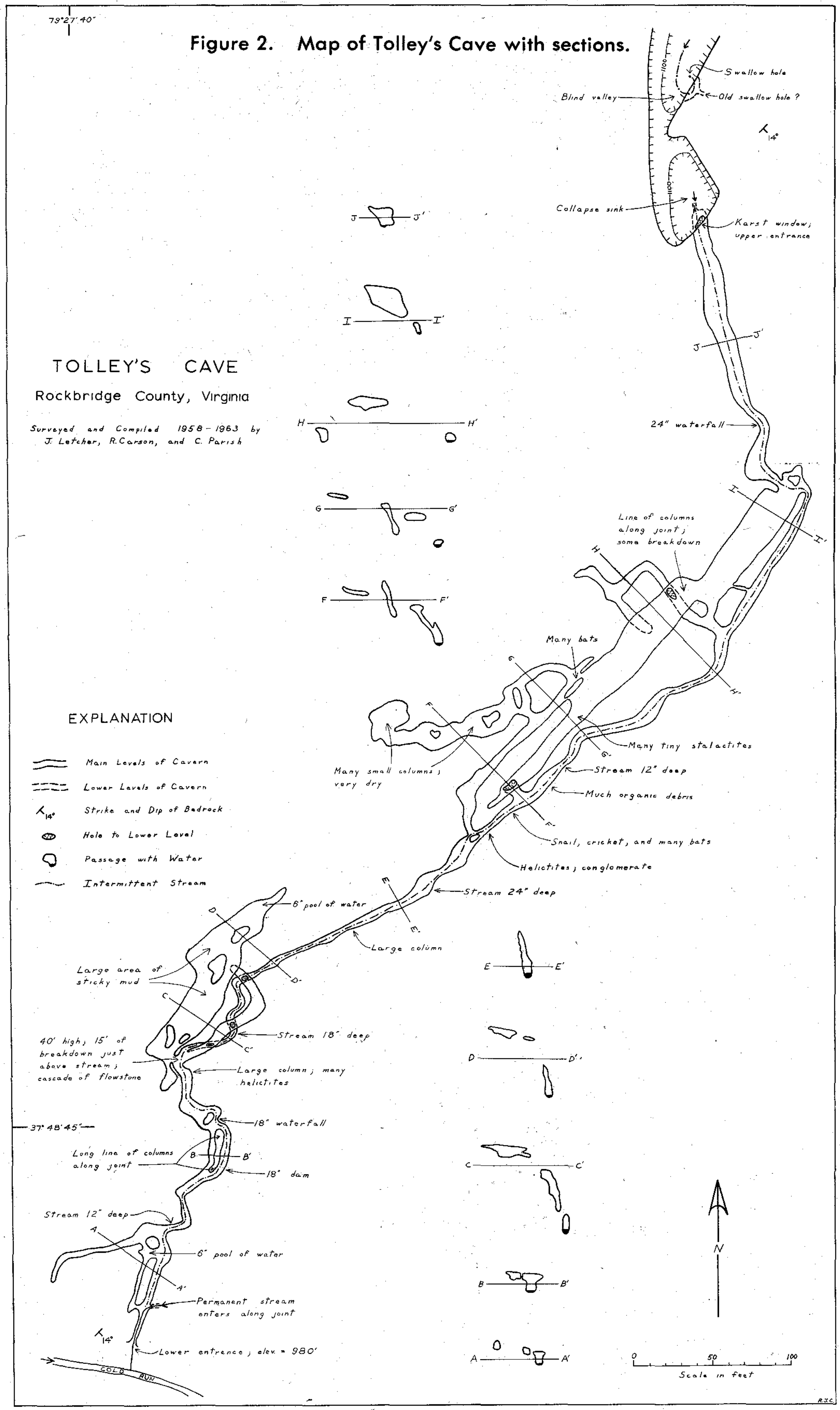

Figure 2. Map of Tolley's Cave with sections.

analysis of a sample of this limestone taken less than 0.5 mile southwest of the cave showed 96.49 percent calcium carbonate.

As shown on the map of Tolley's Cave (Figure 2), the upper entrance to the cavern is a collapse sink located very near the point where an intermittent stream disappears into a blind valley. The lower entrance is 0.2 mile to the south, and from it flows a permanent tributary of Cold Run, a tributary of the Maury River (Figure 3). The elevation of the lower entrance is 980 feet above mean sea level, the upper entrance, 1090 feet. The maximum elevation of the hill above the cavern is 1130 feet. The cavern trends southward for 1100 feet, and has approximately 2200 feet of passages.

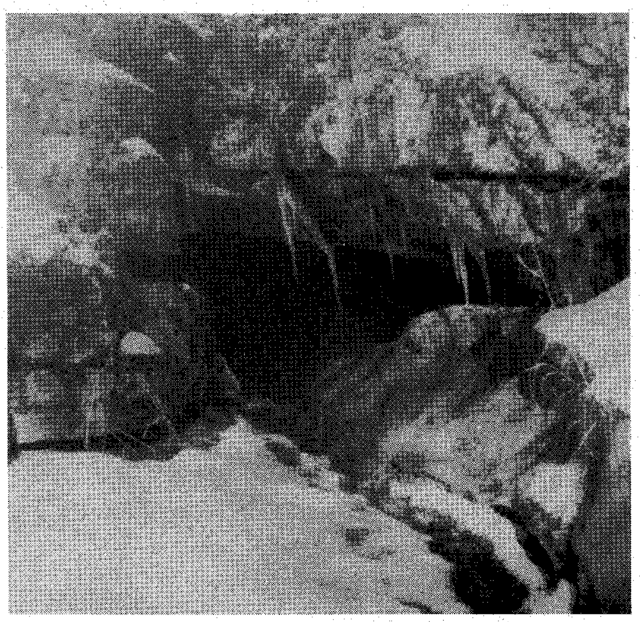

Figure 3. Lower entrance to Tolley's Cave. Solution that produced this opening was concentrated along a joint and a bedding plane.

The map of Tolley's Cave (Figure 2) shows two major types of rooms. There are large rooms, generally low and wide, developed along the strike of the limestone, and there are small rooms, generally high and narrow, developed along the stream. In the small rooms, the stream is apparently joint controlled.

Although the stream is intermittent, in certain parts of the cavern there are permanent large pools of water with mud and rocks at the bottom (Figure 4). In a few places the stream flows across bedrock, and the effect of solution is readily apparent. The streambed generally contains a mixture of material ranging in size from sand to

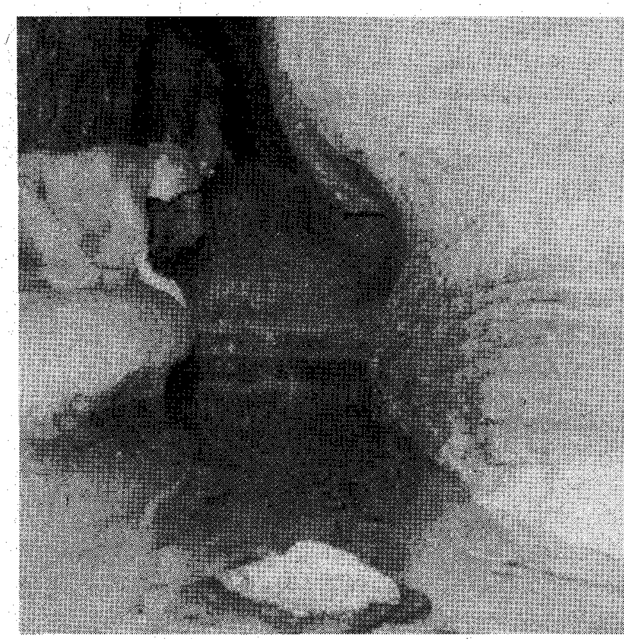

Figure 4. A permanent pool. Walls in the foreground have a thin layer of flowstone; massive flowstone deposits can be seen in the background.

angular blocks up to 15 cubic feet. In one place, breakdown, composed of huge limestone blocks, obstructs the lower part of the passage (Figure 5); the stream passes under the breakdown. The largest rock the stream is capable of moving is approximately 0.5 cubic feet. Whether rocks of this size and smaller are breakdown, or whether they

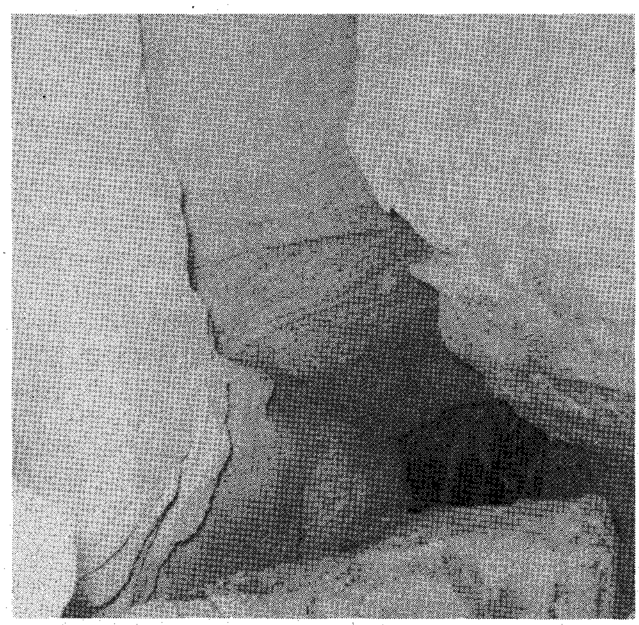

Figure 5. Breakdown. Huge limestone blocks visible in the foreground have obstructed the lower part of the cave passageway.

have been carried into the cavern from the surface, is difficult to determine because the rock at the surface is similar to that in which the cave is formed. At present the intermittent stream in the blind valley disappears into a swallow hole that probably will allow only sand and fine gravel to enter the cavern. However, the rocks in the streambed in the blind valley are similar to those inside the cavern, and in the past the stream may have entered the cavern through a large swallow hole.

The streambed occupies only a small part of the cavern floor. Parts of the floor are covered by breakdown; parts are covered by sticky mud. Much of the floor is covered by dry, loose clay that may be a weathering product of the limestone. Few stalagmites and columns are present on the floor, and in a few places there are shallow pools of water. This cavern differs from many others in that there are no mudcones or stratified mud deposits.

Joints and bedding planes in the walls, ceiling, and ledges are generally masked by weathered surfaces. Some bedrock walls near the stream have weathered very little, and closely spaced joints and bedding planes can be seen. Throughout the bedrock are tiny calcite veins, less than 0.13 inch thick and 2 to 20 feet long; many terminate abruptly. They definitely are not associated with the joints.

Various types of travertine deposits are present. There are groups of small stalactites, stalagmites, and columns (Figure 6), as well as single large stalactites and columns, scattered throughout the cavern. At some places deposits of flowstone, including "bacon-strips" or "organ-pipes", cover entire walls (Figure 7). There seems to be no correlation between the type or amount of travertine and its location; wet and dry, large and small rooms all contain some travertine.

Helictites, found in only a few caverns, are present at two places in Tolley's Cave. One location is southwest of section F-F′ (Figure 2). These small helictites average 1 inch in length. At the second locality, southwest of section C-C′ (Figure 2), the helictites are more numerous. Here they have formed on a large column, on the wall, and in two pools that are about 3 feet above the streambed. There is more flowstone at this locality than at any other place in the cavern. All helictites in Tolley's Cave are either in pools of water or in places that could have once been pools. These helictites may have formed by the process of random growth of individual crystals upon a seed crystal in a pool of water that contained a high concentration of calcium carbonate.

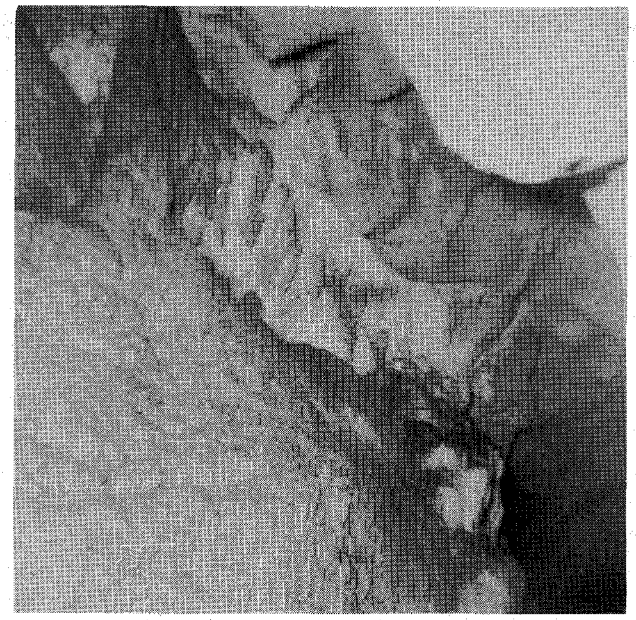

Figure 6. Flowstone covering an entire wall. Small stalactites are present along the ceiling. At this locality the lower passage is connected with one of the low, wide passages in the upper part of the cavern.

Figure 7. "Bacon strips." This type of cave deposit occurs in areas where a large amount of travertine is forming.

One unusual depositional feature in the cavern is a dam located near section B-B′ (Figure 2). The upper portion is a solid mass of travertine, 12 inches high and 6 inches thick, that extends across the passage. The travertine overlies a pile of gravel, 6 inches high, through which water trickles. The water is approximately 12 inches deep behind the dam.

In early spring the water and air temperatures in the cavern are about 52°F. The air temperature inside the cavern varies somewhat with the outside temperature because the cavern has two entrances and is drafty. Because the stream originates on the surface, its temperature inside the cavern also fluctuates.

Tolley's Cave has developed below, at, and above the water table. The low, wide rooms that were formed by the action of ground-water solution below the water table were developed first. This is indicated because they lack the features generally produced by running streams. In comparatively recent time, water moving along joints began to form the high, narrow rooms (Figure 8); this probably occurred at the water table. A surface stream found its way into these enlarged joints and began to connect them into major passages. The stream eventually encountered some of

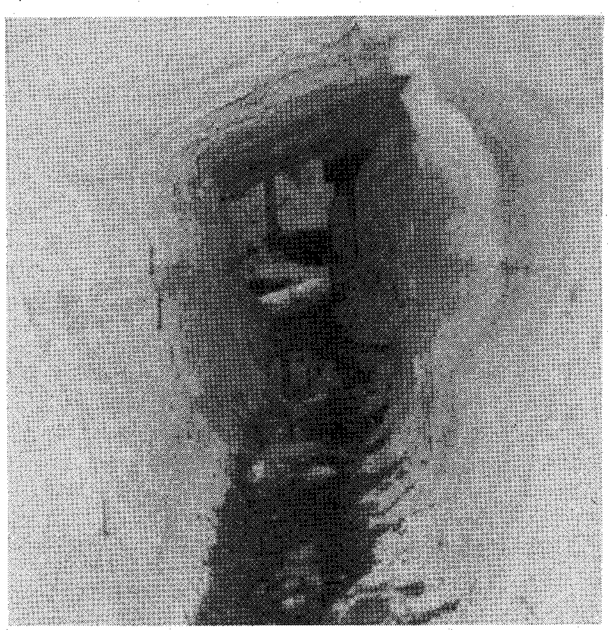

Figure 8. View of the lower entrance from inside the cave. Slope of the ceiling is approximately parallel to the dip of the bedding. A small permanent stream that flows into Cold Run enters the cave a short distance above this point.

the earlier solution openings that were formed below the water table. It is difficult to ascertain whether the long, low room in the northwest parts of sections F-F′ and G-G′ (Figure 2) belonged to the original cavern system, or whether it was incorporated later. Probably the stream originally flowed along the middle passage in section C-C′ (Figure 2) but later, through solution along major joints, dropped to the lower level. The rectangular pattern of the northwest passage in section H-H′ and the west passage in section A-A′ (Figure 2) indicates that they were formerly parts of other underground streams that developed along joints. Another recent development was the formation of the collapse sink at the upper entrance to the cave. The most recent major development was the intersection of the high, narrow stream-formed passage with the long, low passage in the northwest parts of sections C-C′ and D-D′ (Figure 2). This occurred where the stream dissolved away enough limestone to cause a sufficient amount of breakdown to allow the passages to connect. Water seeping from this northwest passage has caused a large amount of flowstone to be deposited along the wall near the breakdown (Figure 7). The passages increased in size mainly through solution by the stream and to a lesser extent by stoping. Stoping includes undercutting of large portions of the wall, breakdown from the ceiling, and the breaking off of more resistant beds when less resistant underlying beds are removed by solution.

While the cavern is being enlarged by solution, it is being reduced in size by the deposition of travertine. Some columns, stalactites, and stalagmites are being formed where ground water seeps into the cavern along joints. Other travertine deposits are forming as water slowly flows over ledges (Figure 6). As the water seeps toward the cavern along joints and bedding planes, it dissolves limestone; the calcium carbonate is then deposited as the water evaporates inside the cavern.

Because cold water holds more calcium carbonate in solution than warm water, the ratio of solution to deposition varies with the seasons. During the winter, water entering the cavern is cold and contains a large amount of calcium carbonate in solution. As this water warms up inside the cavern, carbon dioxide is released and travertine is deposited. On the other hand, in the summer the water entering the cavern is warm and relatively deficient in calcium carbonate. Therefore, as the water enters the cavern and cools down, limestone is dissolved until the water becomes saturated.

Each entrance to the cavern is at the water table, and the permanent stream that flows into the cavern near the lower entrance is also at the level of the water table. It seems likely that the bottom of the cavern is controlled by the water table. As the topography and the water table are lowered, so is the cavern. Increased rainfall results in greater solution activity and promotes more breakdown which can then be carried away due to the increased size and velocity of the stream. Near each entrance and in the higher parts of the cave, there is less flowstone. It is possible that the whole cavern is slowly migrating downward. The bottom is being lowered due to solution activity by the stream at the water table, and the top is being lowered by the deposition of travertine. As the cave migrates downward it may intersect other rooms that have resulted from previous solution and leave behind some of the upper passages.

The lack of mud cones and stratified mud deposits in the cavern is somewhat unusual because this type of deposit is generally present to some extent in nearly all caverns. The minor amount of mud in the cave is either in the streambed or on ledges and parts of the floor. The lack of mud cones and statified mud deposits may result from one or a combination of the following conditions: (1) A greater amount of mud may have been present, but has been periodically flushed out during floods. (2) The limestone is very pure, and solution of about 40 feet of this limestone (maximum height of the cavern) would have produced only a small amount of mud. (3) There is very little water entering the cavern from the surface; this also helps explain the relatively small amount of flowstone.

* * * * *

News Notes

The James River Hydrate and Supply Company, Inc. will open a quarry in mid-spring of 1964 at Gardner, Russell County. Dolomitic limestone will be processed for use as mine dust, highway aggregate, agricultural limestone and for other uses in a $600,000 plant to be constructed at the quarry site. The company presently operates a quarry in dolomite at Buchanan, Botetourt County, where its principal offices are located.

New operations for the production of rock materials have been opened as follows: near Christiansburg, Montgomery County, by Lambert Brothers Division of Vulcan Materials Company; near Glenvar, Roanoke County, by Cardinal Construction Company; near Hanging Rock, Roanoke County, by the Ararat Rock Products Company; and near Clifton Forge, Alleghany County, by the Alleghany Stone and Construction Company. These companies utilize portable plants to produce crushed dolomite, crushed sandstone, crushed limestone, and sand and gravel respectively, for use in construction of the Interstate Highway System.

Radcliff Materials, Inc. of Mobile, Alabama commenced dredging of oyster shells in the vicinity of the Craney Island Disposal Area in Hampton Roads on May 1, 1963. The washed shells are utilized as road material and in the manufacture of cement, lime, chicken feed, and fertilizer.

The Nielson Construction Company of Harrisonburg produces dimension stone for construction of buildings at Madison College from limestone quarries north of Harrisonburg.

Virginia Mineral Industry in 1963

Value of mineral output in Virginia in 1963 was $222.2 million, slightly less than in 1962, but only 2 percent less than the previous record year 1957, according to estimates by the Bureau of Mines, United States Department of the Interior. This marked the eighth consecutive year that the value of Virginia's mineral production has exceeded $200 million. Output of bituminous coal was the third highest year of record, totaling 29.8 million short tons, only 2 percent less than the previous peak in 1961.

Chemical Analyses---Eastern Albemarle and Western Fluvanna Counties

Seymour S. Greenberg

Twenty chemical analyses (Table 1) have been made of metamorphic rocks from eastern Albemarle and western Fluvanna counties. Table 2 shows the rock type, dominant mineralogy, and location of the samples; mineral identification was based on X-ray and petrographic determinations. Reports in which the geologic significance of these analyses is discussed are being prepared. Further information about the analyses or samples will be furnished by the Division upon request.

Table 1. Chemical analyses of some metamorphic rocks from Albemarle and Fluvanna counties, Virginia
(Analyzed by Maynard E. Coller, Geology Department, Indiana University, Bloomington, Indiana).

	Repository Number																			
	2161	2162	2163	2164	2165	2166	2167	2168	2198	2199	2200	2201	2202	2262	2264	2267	2269	2270	2271	2273
% SiO_2	46.4	42.0	61.6	59.4	58.8	66.6	54.6	58.0	45.0	43.7	71.3	62.0	55.5	47.0	45.0	43.0	42.8	42.1	47.6	45.8
% Al_2O_3	28.7	29.7	18.9	20.7	20.8	15.1	23.1	20.8	31.3	30.4	15.0	18.2	24.1	21.0	15.4	11.3	6.28	10.7	20.5	16.3
% Fe_2O_3	7.62	13.6	7.57	6.55	2.81	2.24	7.07	5.86	10.4	11.7	0.35	7.36	3.51	2.28	N.D.	0.90	2.74	0.83	2.99	3.07
% FeO	1.87	1.20	2.13	0.93	3.20	3.40	1.47	1.13	0.53	0.60	4.15	1.60	4.27	4.07	15.8	9.34	5.87	9.40	8.27	10.7
% TiO_2	1.16	1.27	0.84	0.45	0.77	0.65	1.01	0.91	0.82	0.84	0.24	0.43	0.65	0.54	1.08	0.41	0.26	0.37	1.31	2.24
% CaO	N.D.	N.D.	0.05	0.08	0.55	2.57	0.03	0.29	0.05	N.D.	0.31	0.05	0.08	13.2	3.43	3.02	2.94	6.53	9.52	10.5
% MgO	1.24	0.67	1.10	0.99	1.79	1.77	1.12	1.81	0.39	0.36	1.39	1.16	1.33	5.93	9.04	23.7	28.0	22.1	3.18	4.71
% Na_2O	0.57	2.40	1.14	0.03	0.15	2.85	0.05	1.21	2.01	1.33	2.08	0.55	1.29	1.91	1.43	0.05	0.01	0.05	2.60	2.42
% K_2O	6.62	3.88	2.58	3.50	6.21	2.29	4.16	3.17	3.93	3.91	1.88	1.98	3.80	0.47	0.07	0.02	0.01	0.03	0.07	0.26
% CO_2	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.03	0.13	N.D.	1.45	N.D.	4.36	N.D.	0.11	0.17
% H_2O (−)	0.45	0.46	0.25	2.01	0.35	0.13	0.73	1.32	0.45	0.66	0.12	0.50	0.34	0.31	0.14	0.33	0.07	0.81	0.22	0.52
% H_2O (+)	4.85	4.58	3.12	4.85	3.86	1.64	5.87	4.66	4.44	5.88	2.63	4.70	4.76	3.12	6.32	7.69	6.21	6.40	3.52	2.70

N.D.—Not detected.

Table 2. Rock type, significant minerals and location of samples that were analyzed chemically.

Repository Number	Rock Type	Significant Minerals	Location
2161	Phyllite	Muscovite, chlorite	NE side of road at Paynes Mill, 0.15 mile SE of lake; Fluvanna Co.
2162	Phyllite	Muscovite, paragonite, hematite	On north side of road, 1.1 miles west of Union Mills, and 0.2 mile west of intersection of road and Oliver Creek; Fluvanna Co.
2163	Phyllite	Quartz, muscovite, chlorite, paragonite	On east bank of Mechum Creek, 1 mile east of Union Church and 0.53 mile north of intersection of Oliver and Mechum creeks; Fluvanna Co.
2164	Weathered phyllite	Mixed-layer clays, kaolinite, quartz, muscovite	In bottom of stream that is tributary to south fork of Cunningham Creek, 0.4 mile ENE of Wesley Chapel; Fluvanna Co.
2165	Phyllite	Muscovite, quartz, biotite, plagioclase	In Cedar Branch, 0.5 mile ENE of junction of Cedar Branch and Stigger Creek; Fluvanna Co.
2166	Metamorphosed graywacke	Quartz, plagioclase, muscovite, biotite, epidote	In Cunningham Creek, 1.9 miles SSE of Haden Chapel and 1.85 miles NNE of Little Rock Church; Fluvanna Co.
2167	Weathered phyllite	Kaolinite, quartz, muscovite, goethite	Along west bank of road, 1.75 miles NNE of Palmyra and 2 miles SSE of Wildwood; Fluvanna Co.
2168	Argillite	Muscovite, quartz, vermiculite, plagioclase	Along north bank of secondary road, 0.4 mile NE of Little Rock Church; Fluvanna Co.
2198	Phyllite	Muscovite, paragonite, hematite, K-feldspar	On south side of State Highway 20, 0.95 mile SW of Rose Hill Church; Albemarle Co.
2199	Weathered phyllite	Muscovite, paragonite, kaolinite, goethite	On north side of State Road 708, 0.3 mile SE of Blenheim; Albemarle Co.
2200	Metamorphosed graywacke	Quartz, chlorite, muscovite, plagioclase	In bluff on SE side of Hardware River, 0.7 mile NW of Jefferson Mill; Albemarle Co.
2201	Phyllite	Quartz, muscovite, chlorite	On west side of State Road 620, 0.15 mile north of Woodridge; Albemarle Co.
2202	Phyllite	Muscovite, chlorite, quartz, paragonite, K-feldspar	On NE side of State Road 795, 1.4 miles NE of Blenheim; Albemarle Co.
2262	Amphibolite	Plagioclase, amphibole, mica, quartz, clinozoisite	On south side of State Highway 6, 0.9 mile SSW of Oak Ridge School; Albemarle Co.
2264	Chlorite schist	Chlorite, plagioclase, calcite	On south bank of railroad cut, 0.85 mile SW of Oak Ridge School; Albemarle Co.
2267	Amphibolite	Amphibole, chlorite, talc	On hill, 0.25 mile SW of Oak Ridge School; Albemarle Co.
2169	Soapstone	Talc, chlorite, dolomite	South quarry of Old Dominion soapstone quarries, Old Dominion; Albemarle Co.
2270	Amphibolite	Amphibole, chlorite	On SE side of farm road, 1.1 miles NNE of Oak Ridge School; Albemarle Co.
2271	Amphibolite	Chlorite, amphibole, plagioclase, clinozoisite, quartz	On north side of abandoned railroad, 0.6 mile NE of Oak Ridge School; Albemarle Co.
2273	Amphibolite	Plagioclase, amphibole, quartz, chlorite	At SE corner of intersection of State Road 630 and State Highway 6; Albemarle Co.

Division of Mineral Resources
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Form 3547 Requested

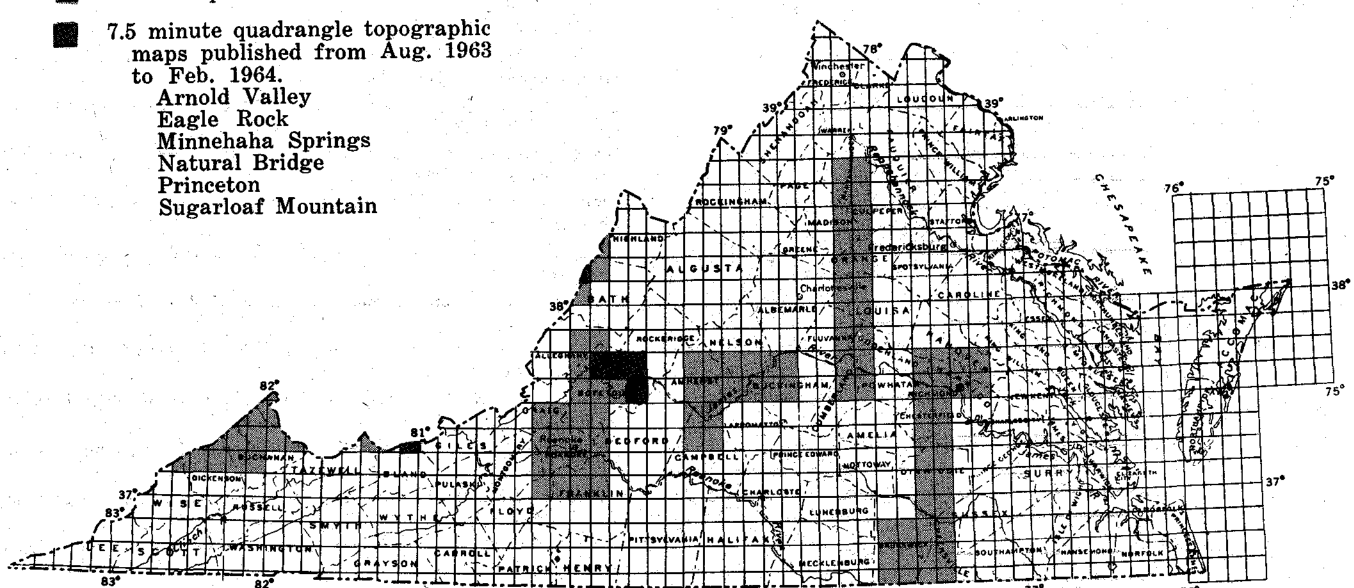
Rock and Mineral Collections Available

To promote and stimulate interest in Virginia's mineral resources that are utilized as basic raw materials in industrial processes, the Division is making available a rock and mineral collection similar to that prepared in 1959 for school use. Each set contains 25 specimens of rocks and minerals packed in an attractive display box, a booklet with a description of each specimen, and a general location map. These collections may be purchased at a cost of $5.00 each by residents of Virginia. Order from the Division of Mineral Resources, Box 3667, University Station, Charlottesville, Virginia.

TOPOGRAPHIC MAPS

Advance prints

7.5 minute quadrangle topographic maps published from Aug. 1963 to Feb. 1964.
- Arnold Valley
- Eagle Rock
- Minnehaha Springs
- Natural Bridge
- Princeton
- Sugarloaf Mountain



ADVANCE PRINTS

Advance prints (blue line) are available at 50 cents each from the U. S. Geological Survey, Topographic Division, 1109 N. Highland St., Arlington, Va.

PUBLISHED MAPS

State index is available free. Published maps are available at 30 cents each from the Virginia Division of Mineral Resources, Box 3667, University Station, Charlottesville, Virginia.